Optical Measurements in Furnaces as Diagnostic Tool for Combustion Processes in Power Plants

Clausen, Sønnik

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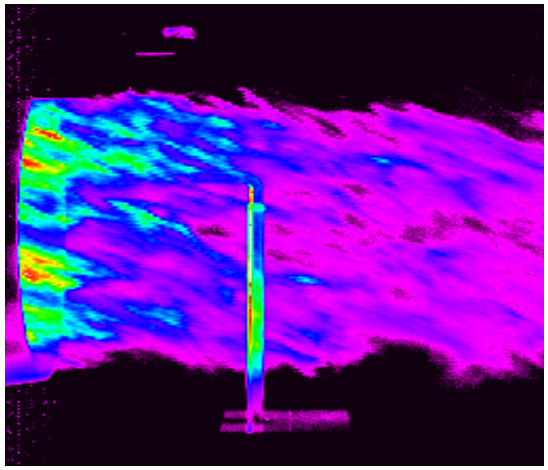
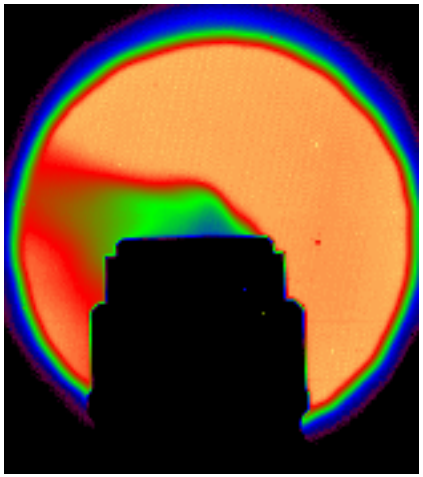




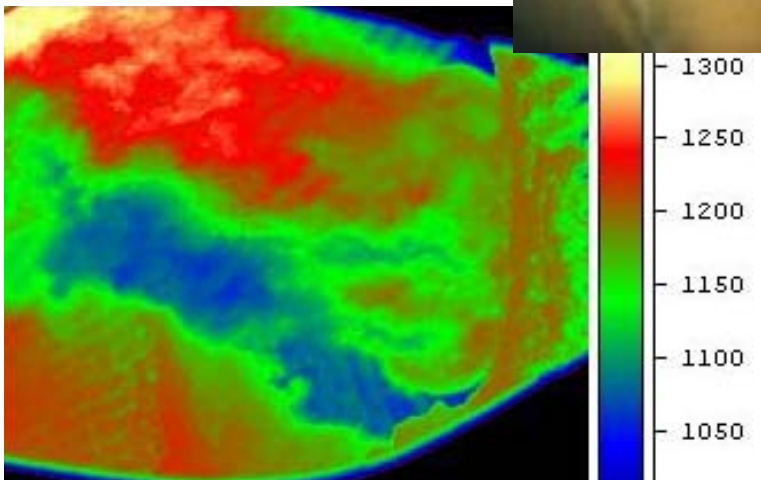
Risø DTU

Sønnik Clausen

+45 20814523, sqcl@risoe.dtu.dk

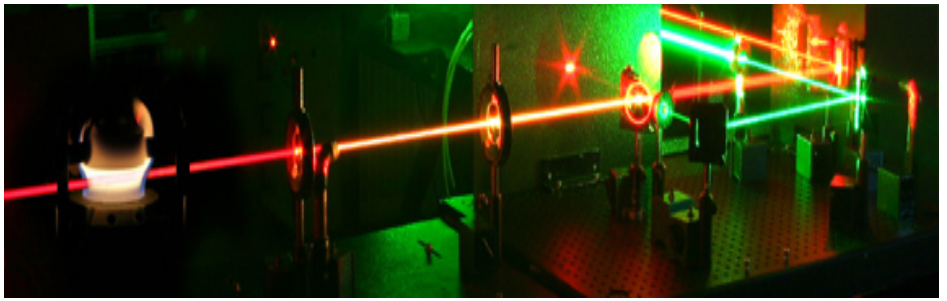
Optical Measurements

- Short measurement time
- Non-contact
- Multi-parameters
- …



- Optical access
- Strong absorption
- Complex equipment
- Clean window
- …

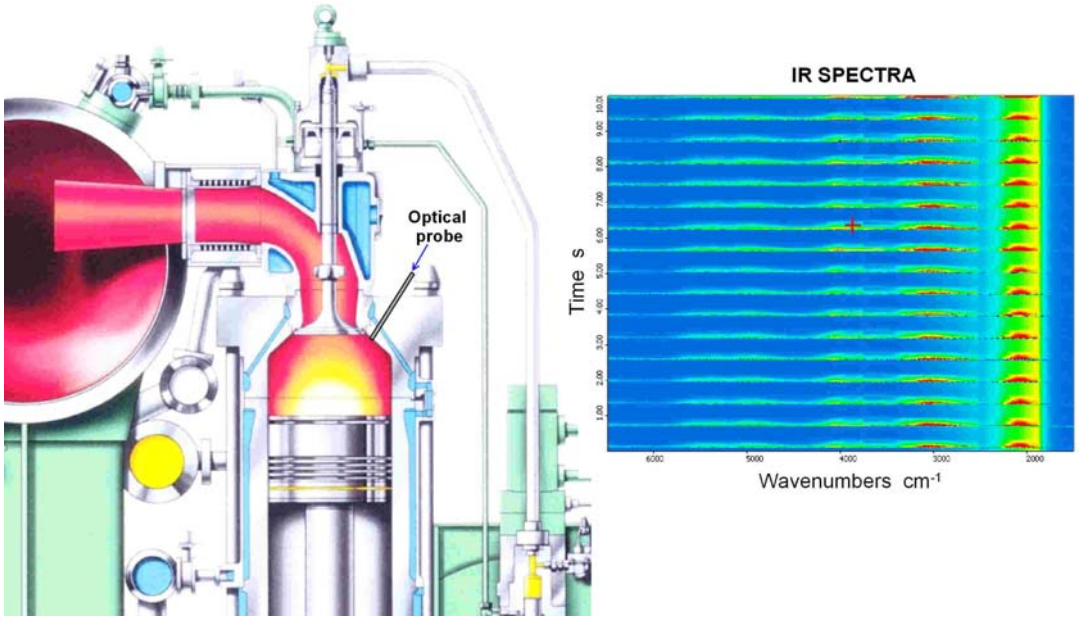
http://www.forbrf.lth.se/forskning



OPTICAL MEASUREMENTS

Research and development of optical methods….
Improve, optimise existing and new combustion processes, R&D new energy technologies, etc.

- **POWER PLANTS**
- **ENGINES**
- **STEEL, INSULATION**
- **PROCESS INDUSTRY**
- **R&D NEW ENERGY**
- **ENVIRONMENT**
- **etc.**

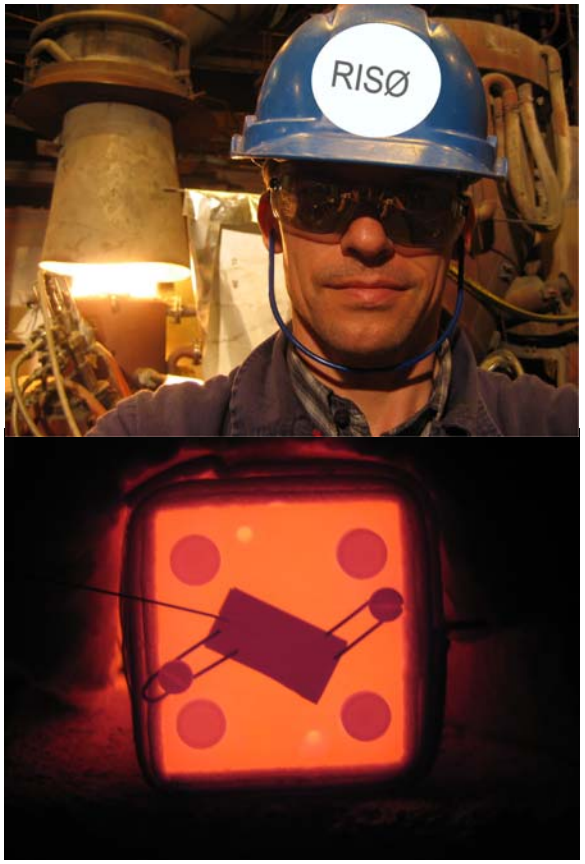


CORE: **TEMPERATURE**

OPTICAL DIAGNOSTICS?

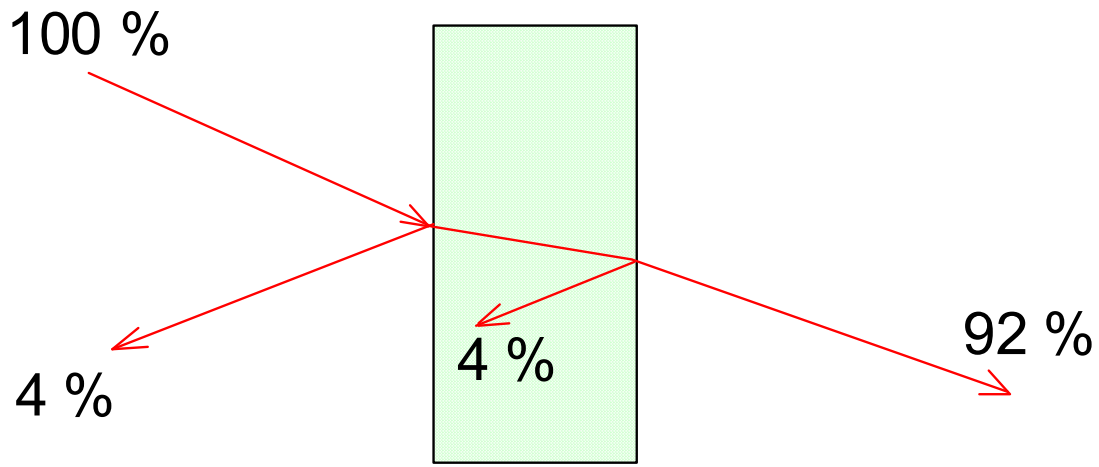
- TEMPERATURE, HEAT FLUX, …
- GAS COMPOSITION
- PARTICLE SIZE,
- VELOCITY
- EMISSIVITY of SURFACES
- IMAGING, VISUALISATION,…
- DEPOSITES, LEAKS,…

- SENSORS

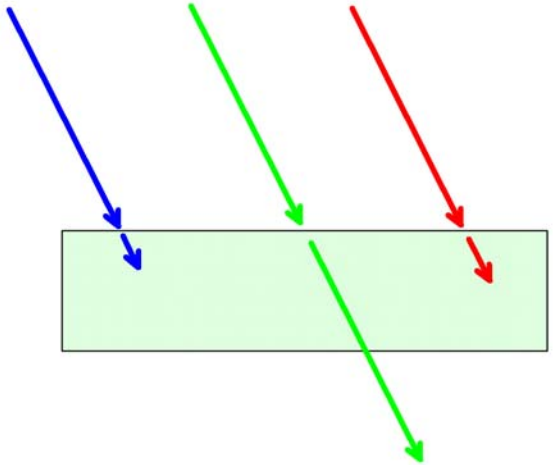


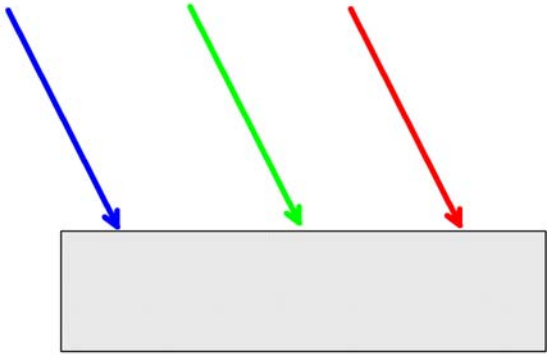
Properties of Light

$$t + r + a + s = 1$$



ABSORPTION

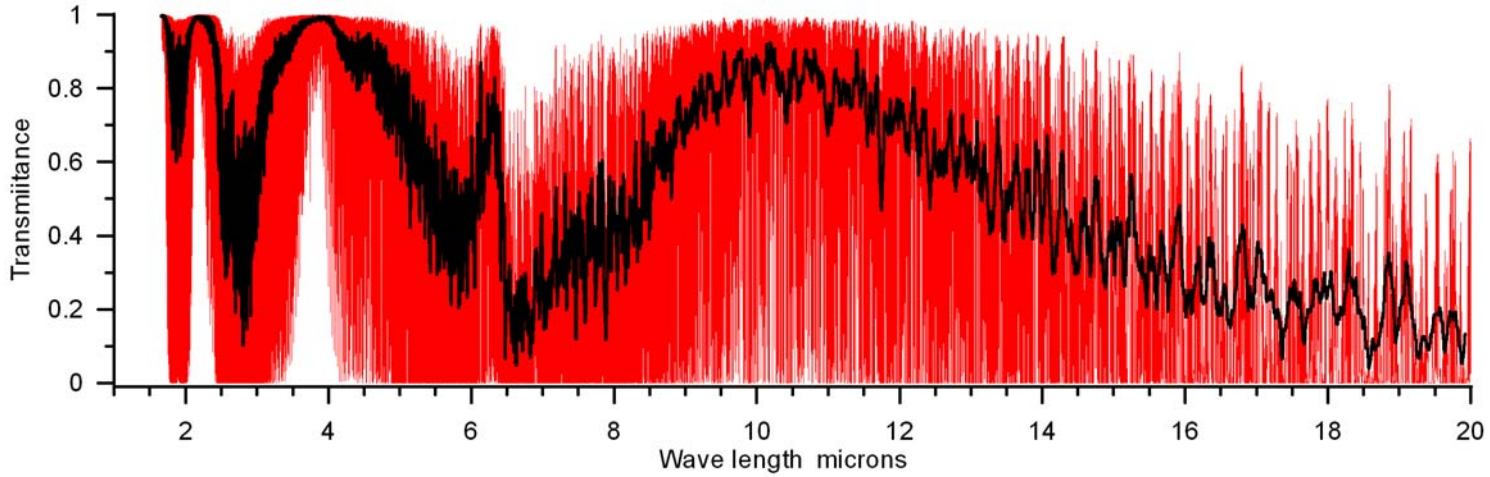


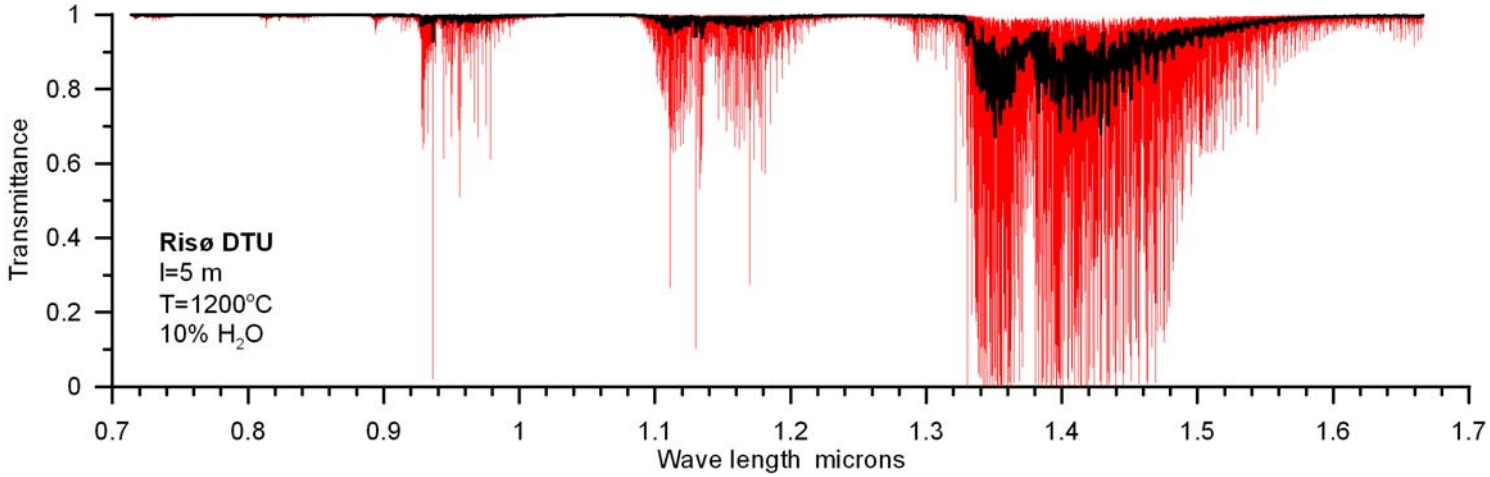


Beer's Lov:

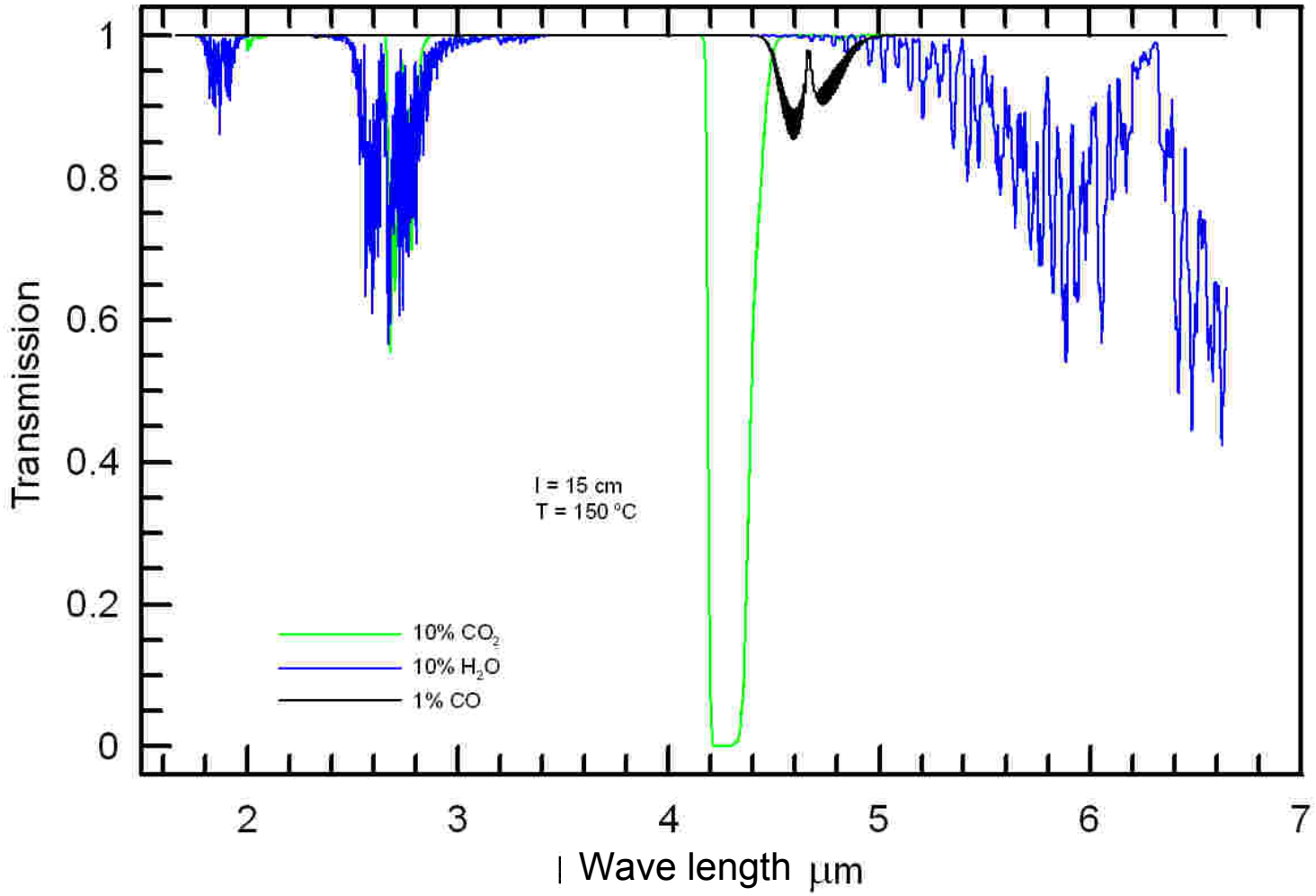
$$I = I_0 e^{-abc}$$

Absorption water

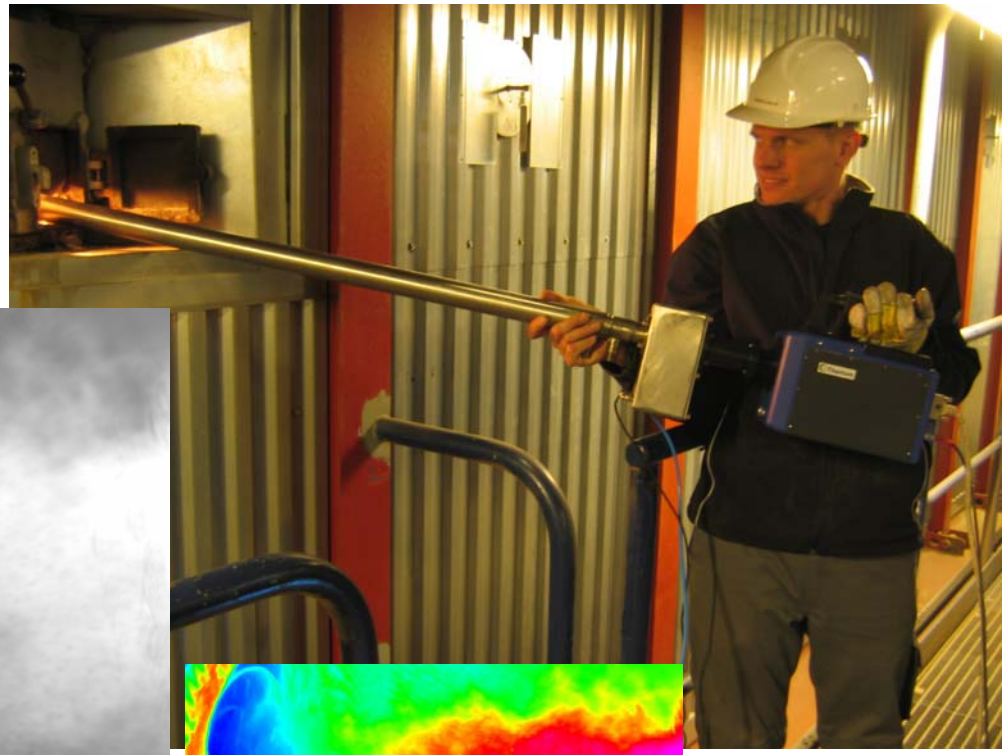


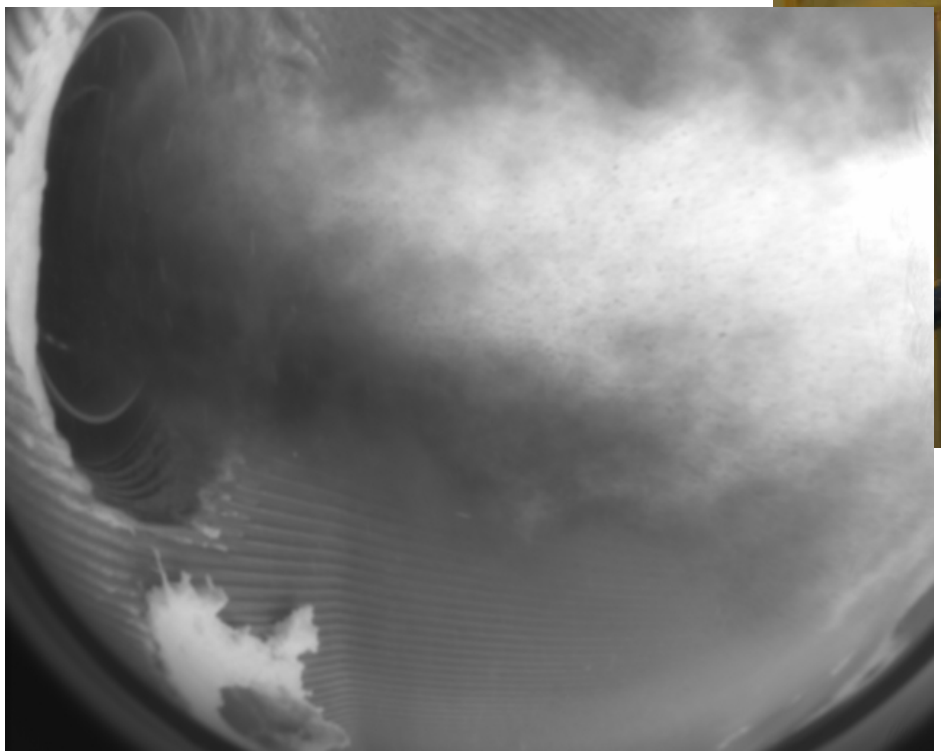


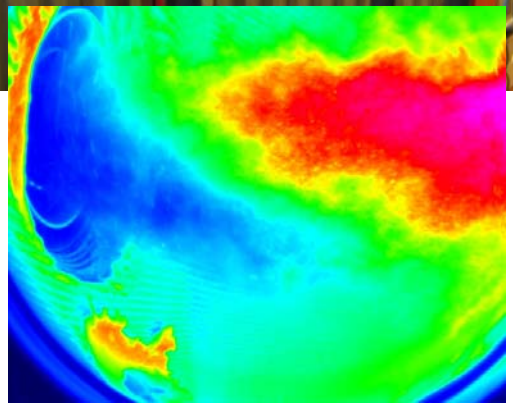
IR absorption flue gas



Thermal imaging of flame

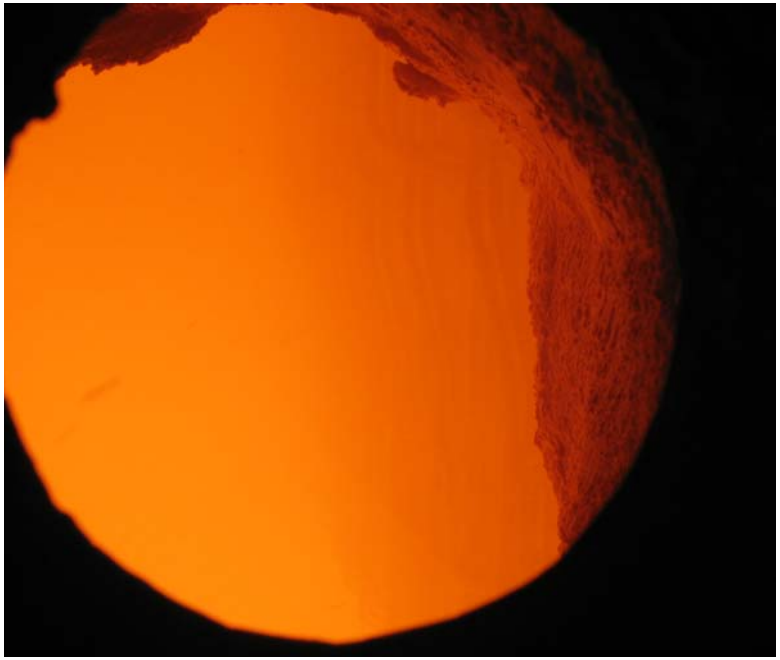




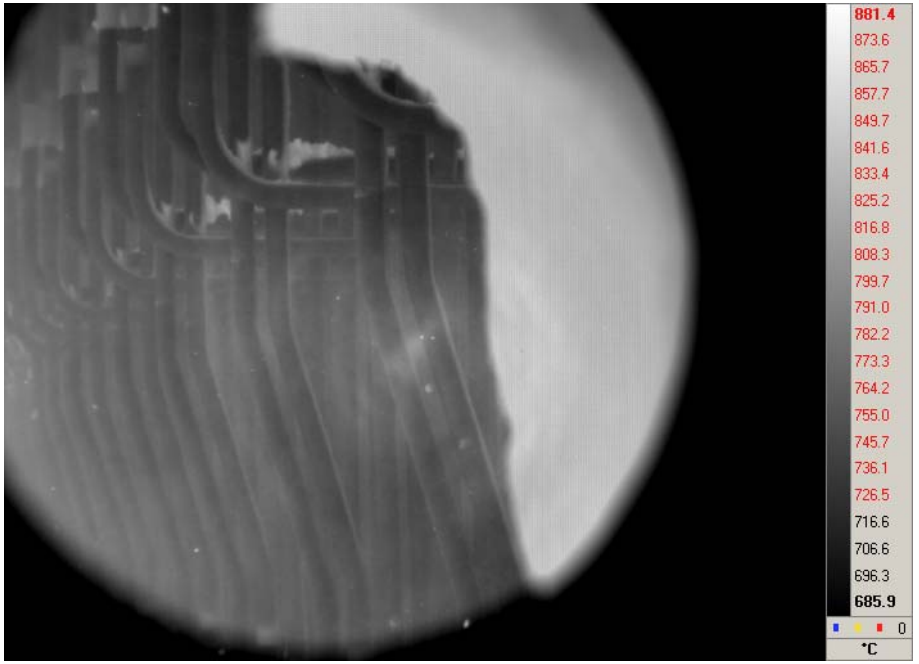


VIS versus IR

SUPER HEATER FYNSVÆRKET

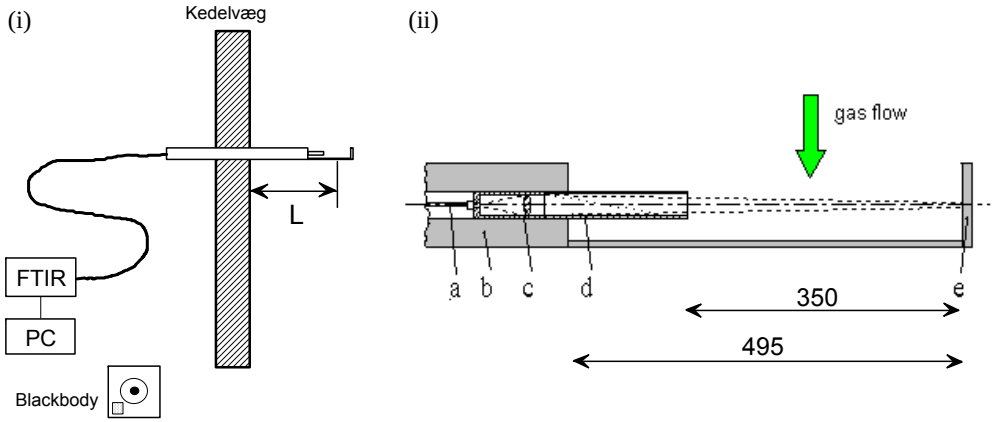


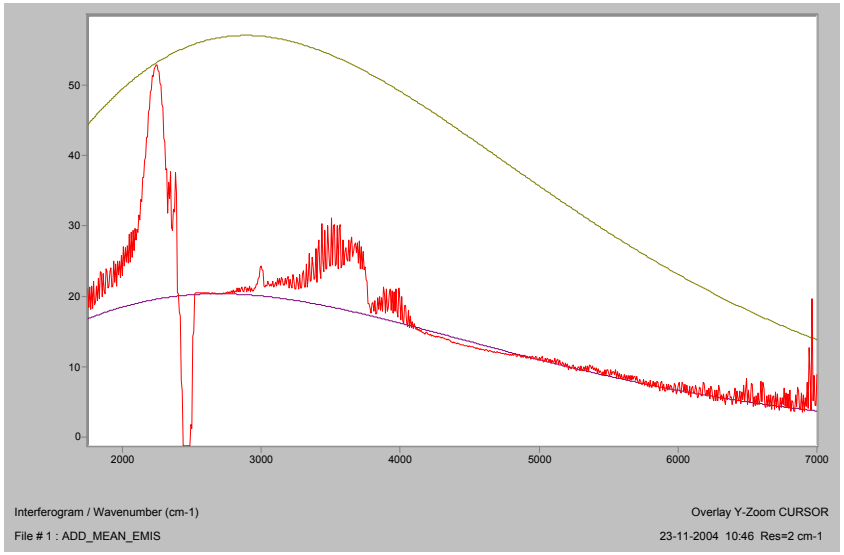
VIS / VIDEO

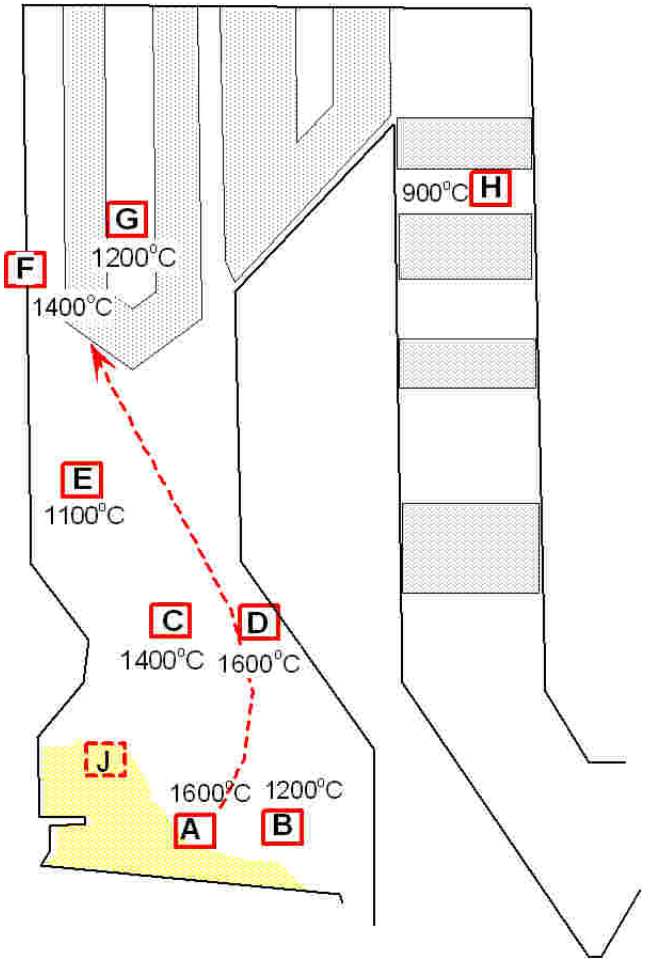


IR

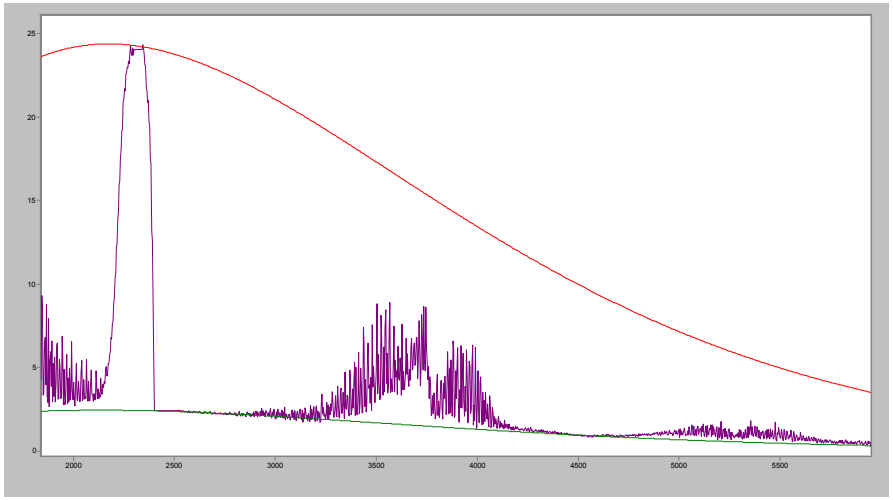
IR SPECTROSCOPY POWER PLANT





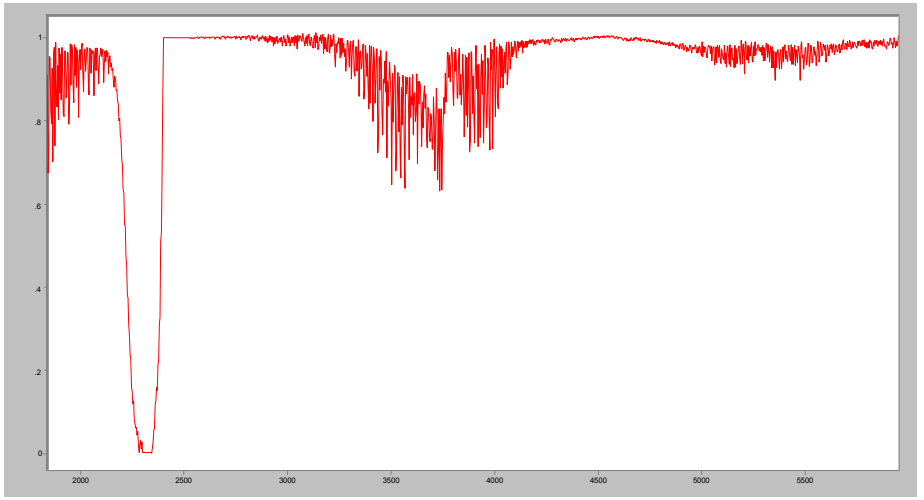


FTIR Fiber-Optics

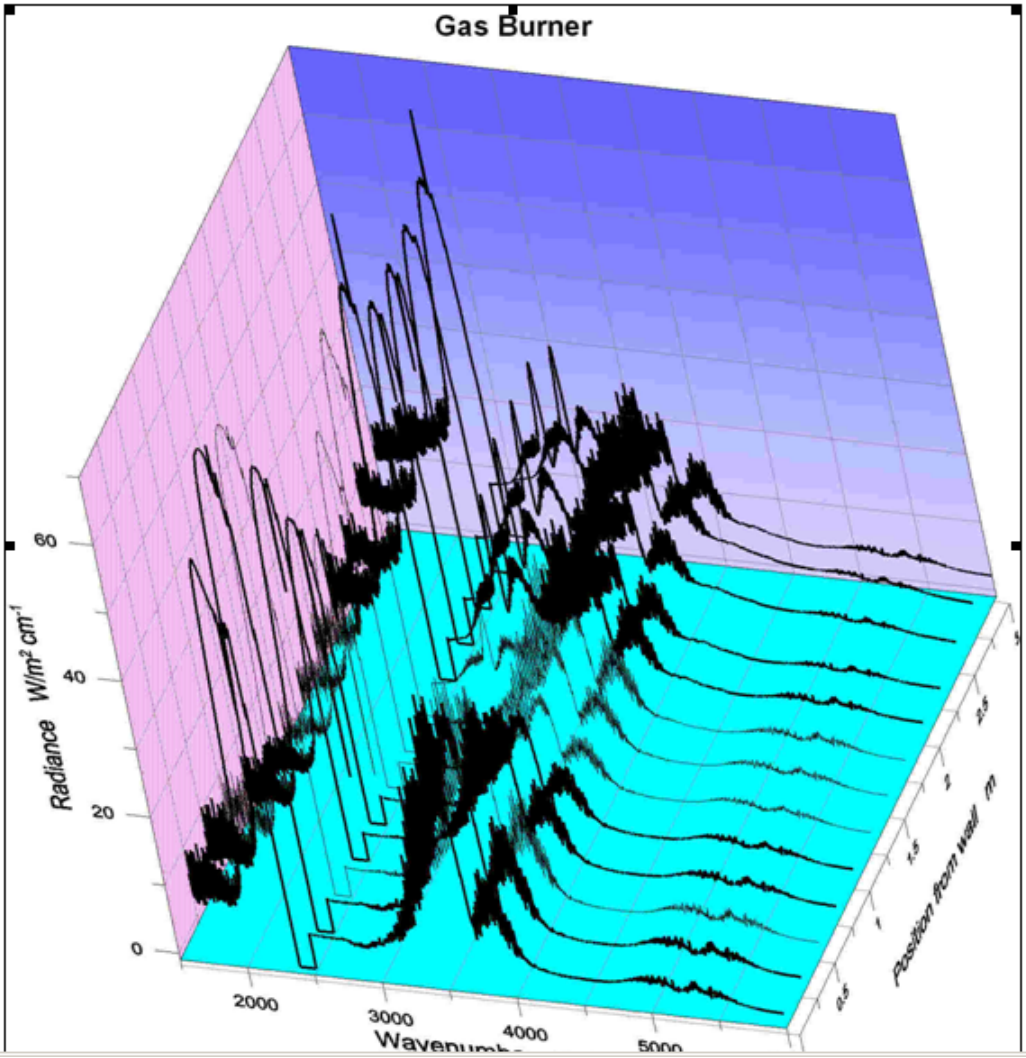


Emission spectrum:
GB: 816.9ºC, ε=0.106
Blackbody curve at 836.0ºC

Transmittance spectrum
CO_2, H_2O, CO, C_xH_y, …



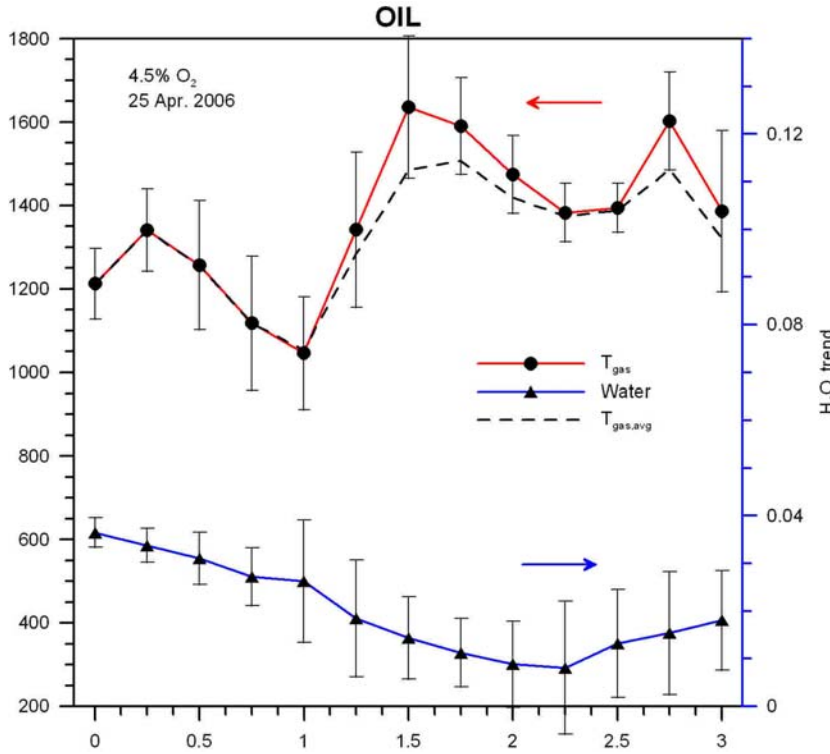
IR spectra

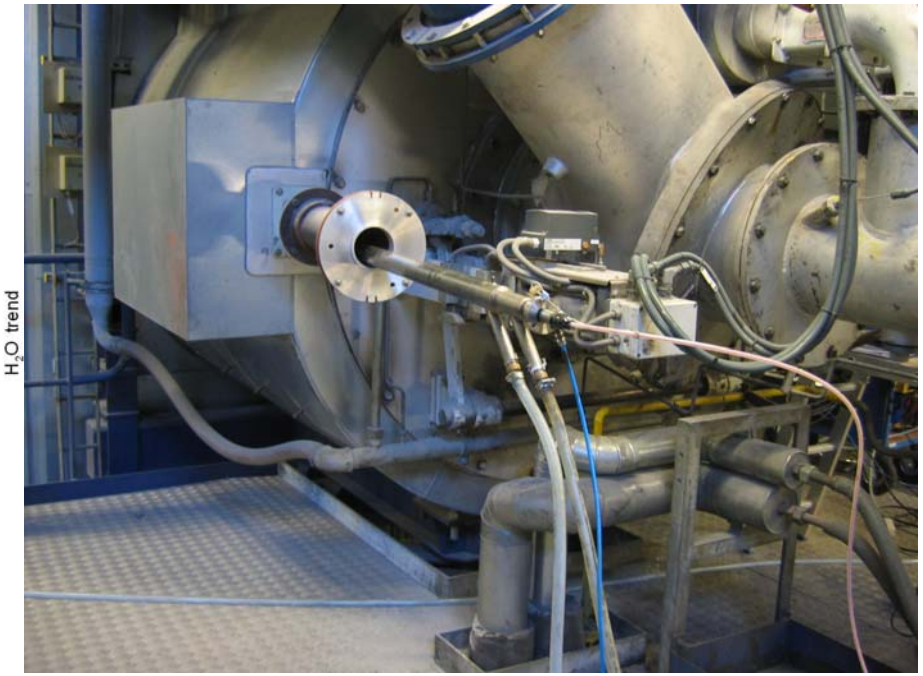

Gas Burner
Radiance W/m² cm⁻¹
60
40
20
0
2000
3000
4000
5000
Position from wall m
0.5
1
1.5
2
2.5

FTIR SPECTROSCOPY

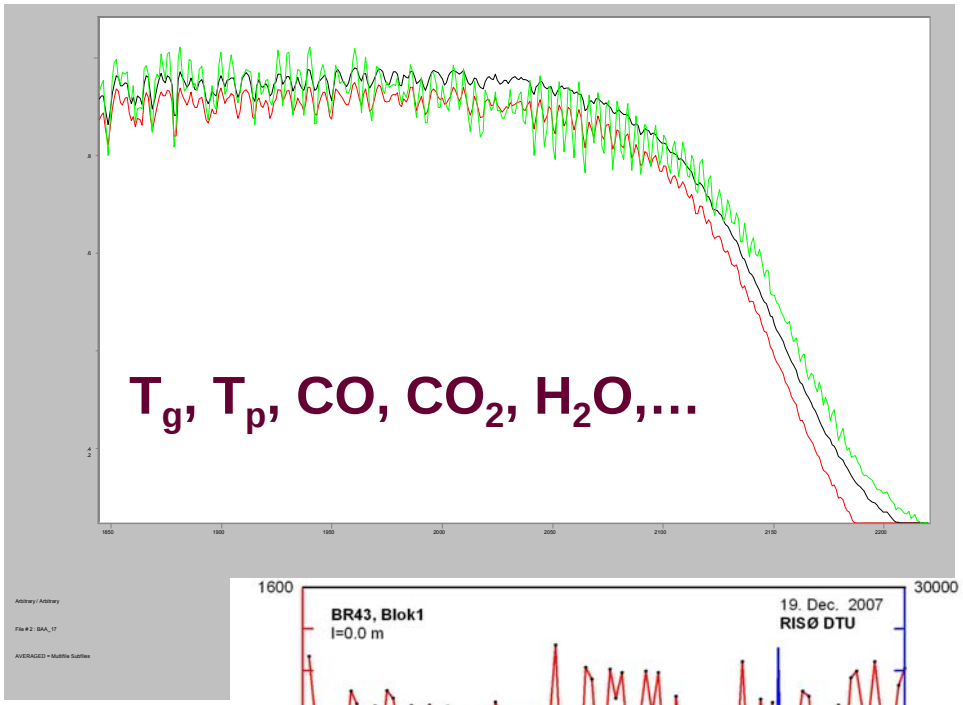
Simultaneously
temperature and concentration

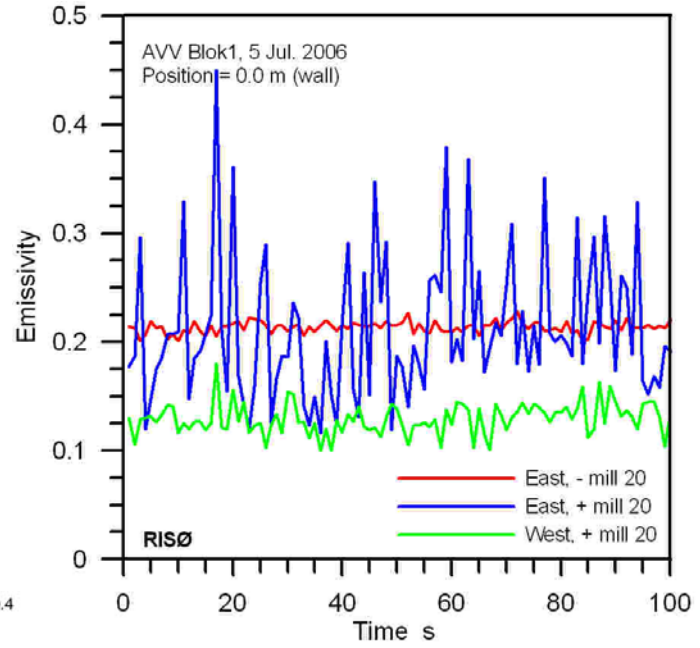
VERIFICATION
methods and results

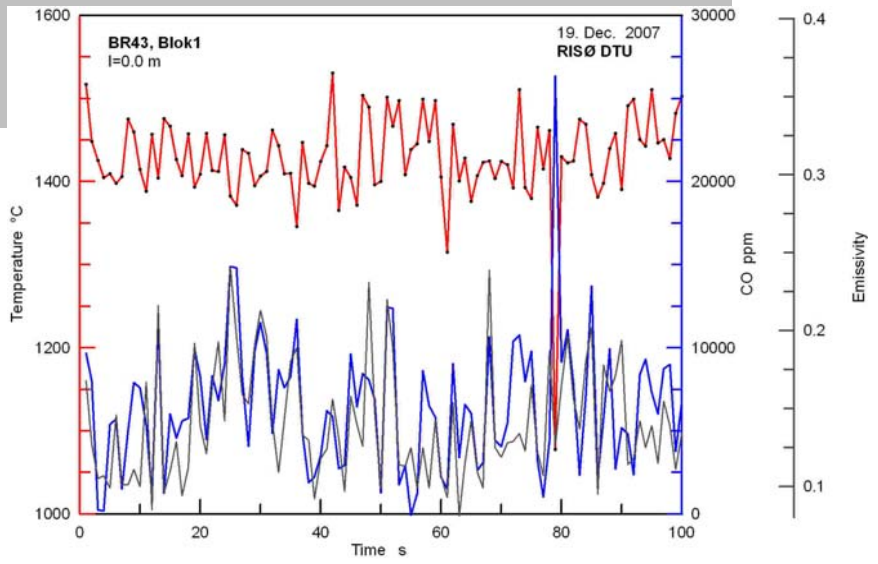




CO Corrosion Wall

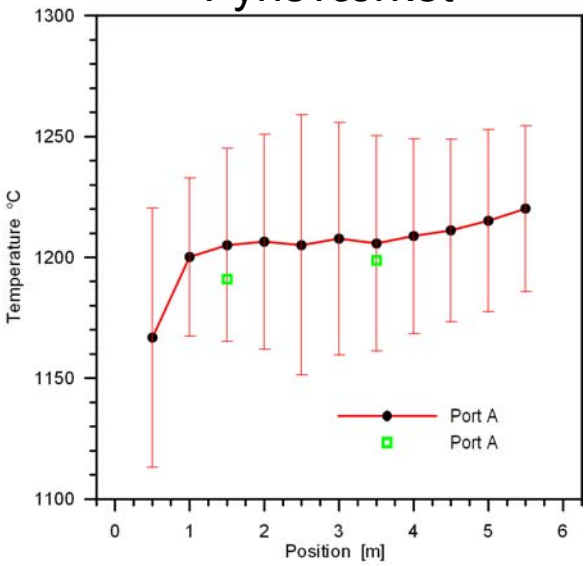


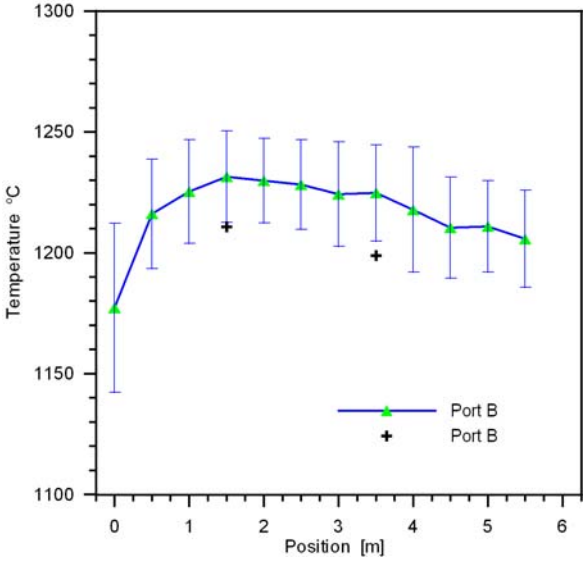




Mixing of Flows

Fynsværket

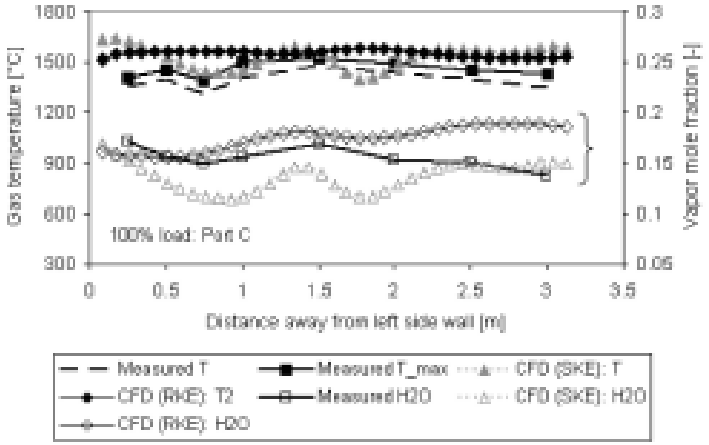




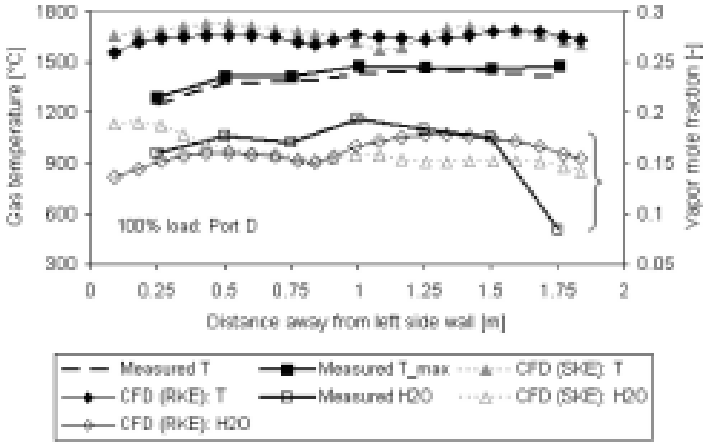
MIXING COLD AND HOT AIR IS LIKE MIXING WATER AND OIL

Pictures are recorded with 10 ms between pictures and 333μs exposure time.

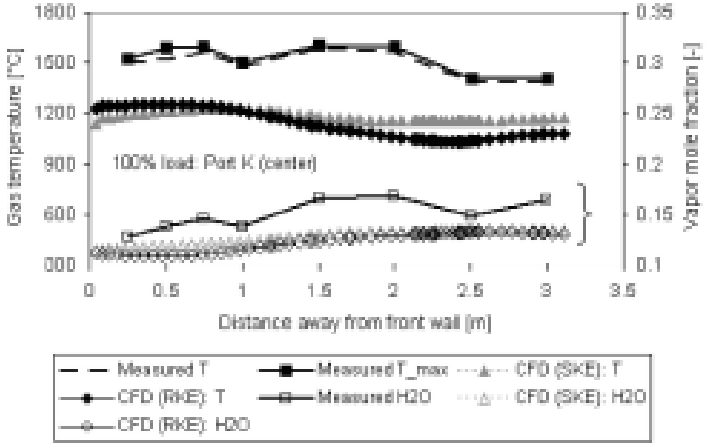
CFD Validation



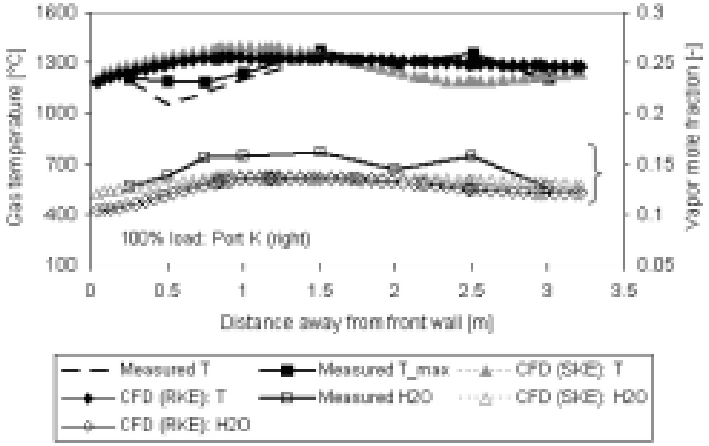
(a) At Port C



(b) At Port D



(c) At Port K (center)

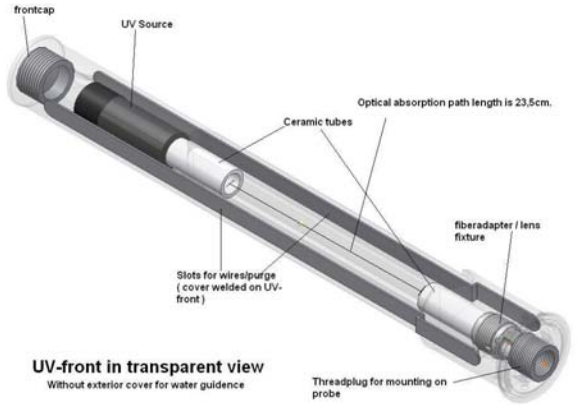


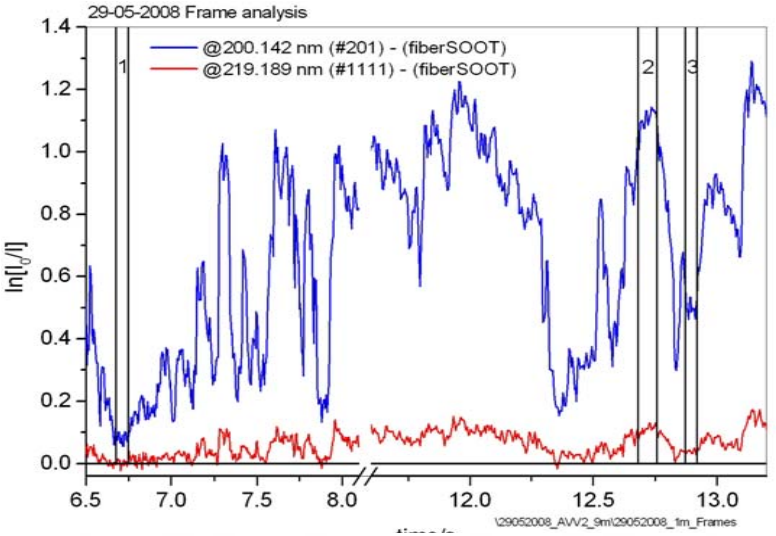
(d) At Port K (right)

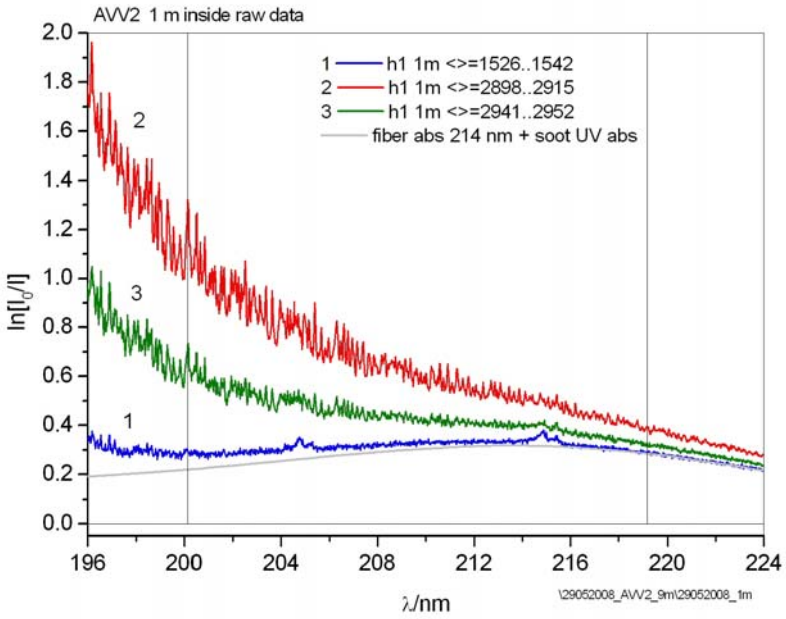
Figure 11. CFD results vs FTIR measurements at four of the measuring ports at 100% load.

Energy & Fuels 2008, 22, 1380–1390

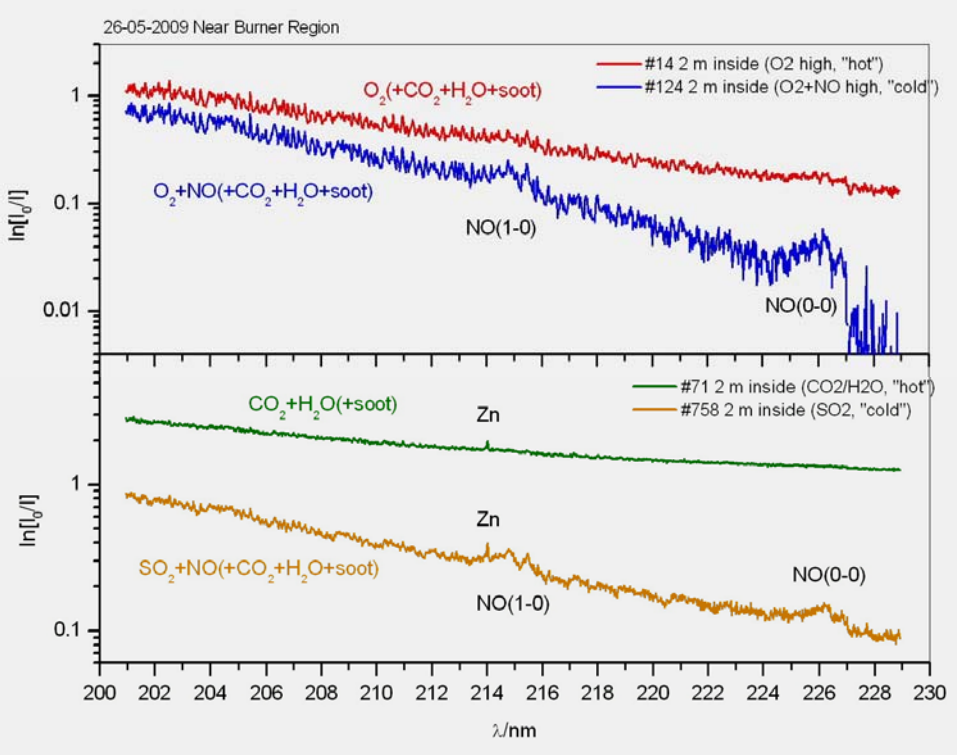
UV SPECTROSCOPY







Fast UV absorption measurements in Near Burner Region (coal)



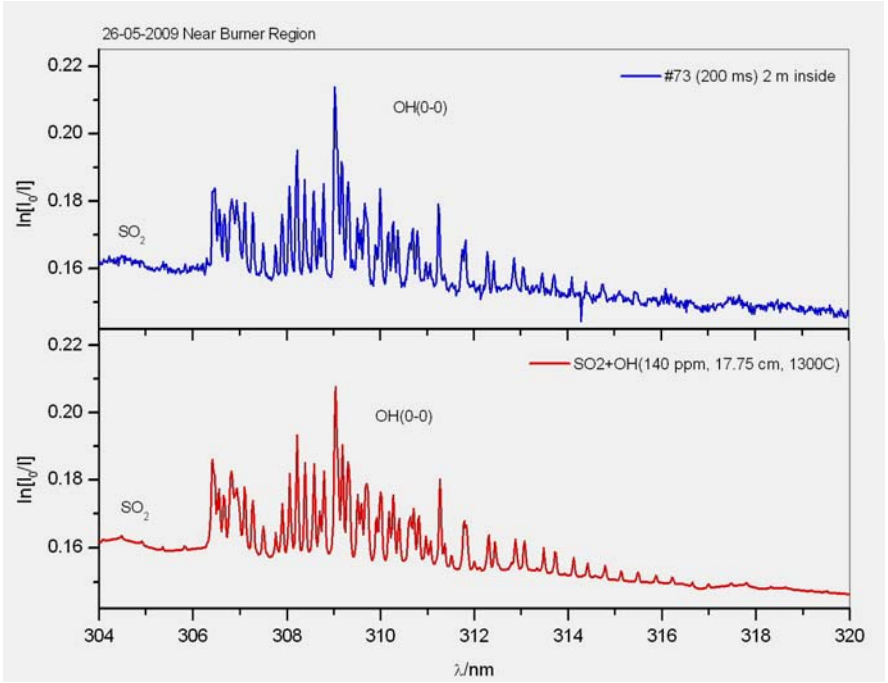
UV head (L up to 23.5 cm): 17.75 cm

1 ms exposure + 4.38 ms readout

in flame UV broad band absorption:

T_{gas}, NO, O_2, SO_2, H_2O, CO_2, OH, soot

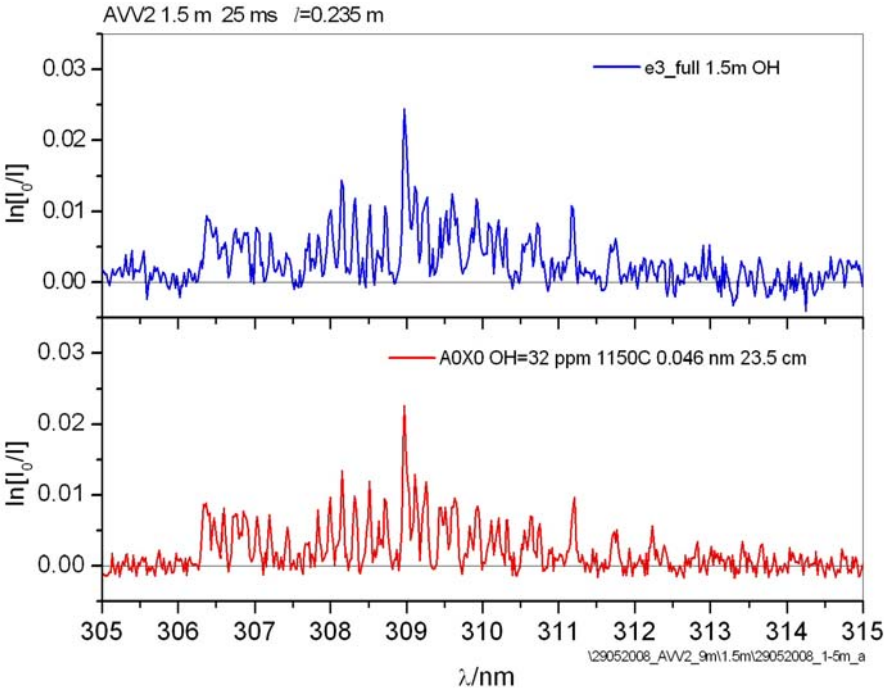
$$\ln\left[\frac{I_0(\lambda)}{I(\lambda)}\right] = \sigma(\lambda,T)\cdot L\cdot[Gas]$$

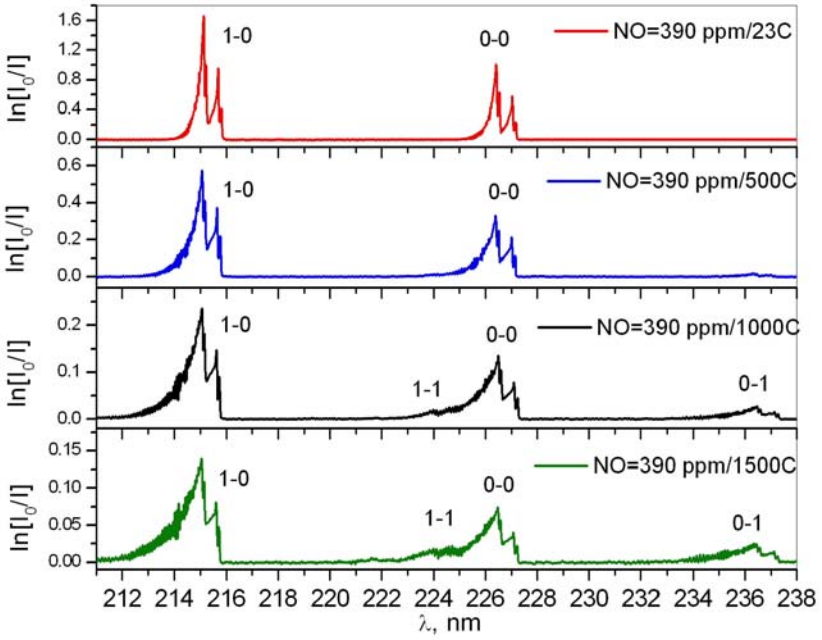


HOT GAS FACILITY

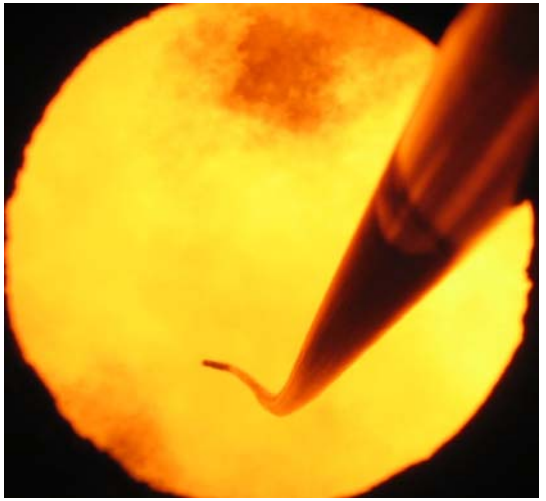
REFERENCE DATA
optical properties of gases

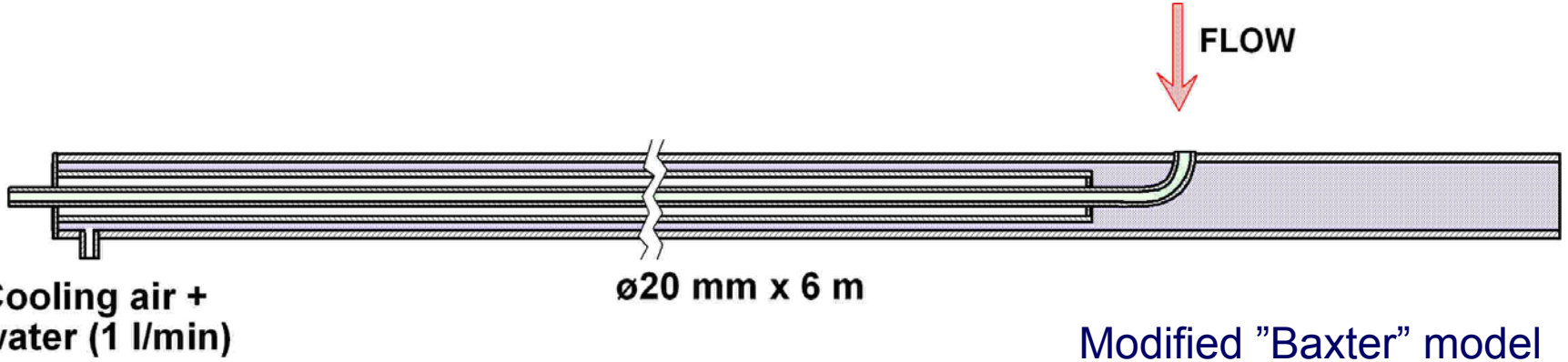
VERIFICATION
methods and results





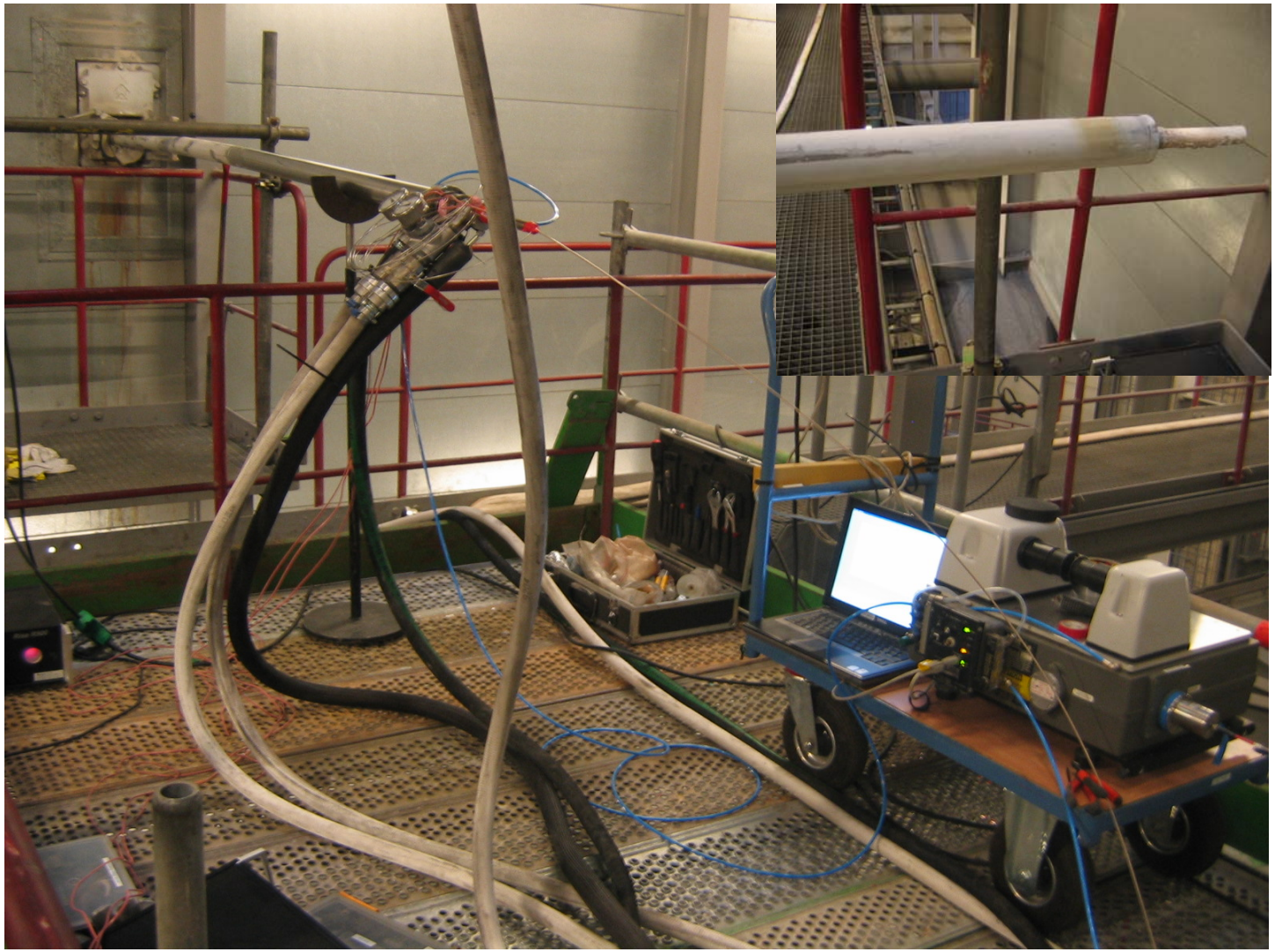
Ekstractive Flex Probe



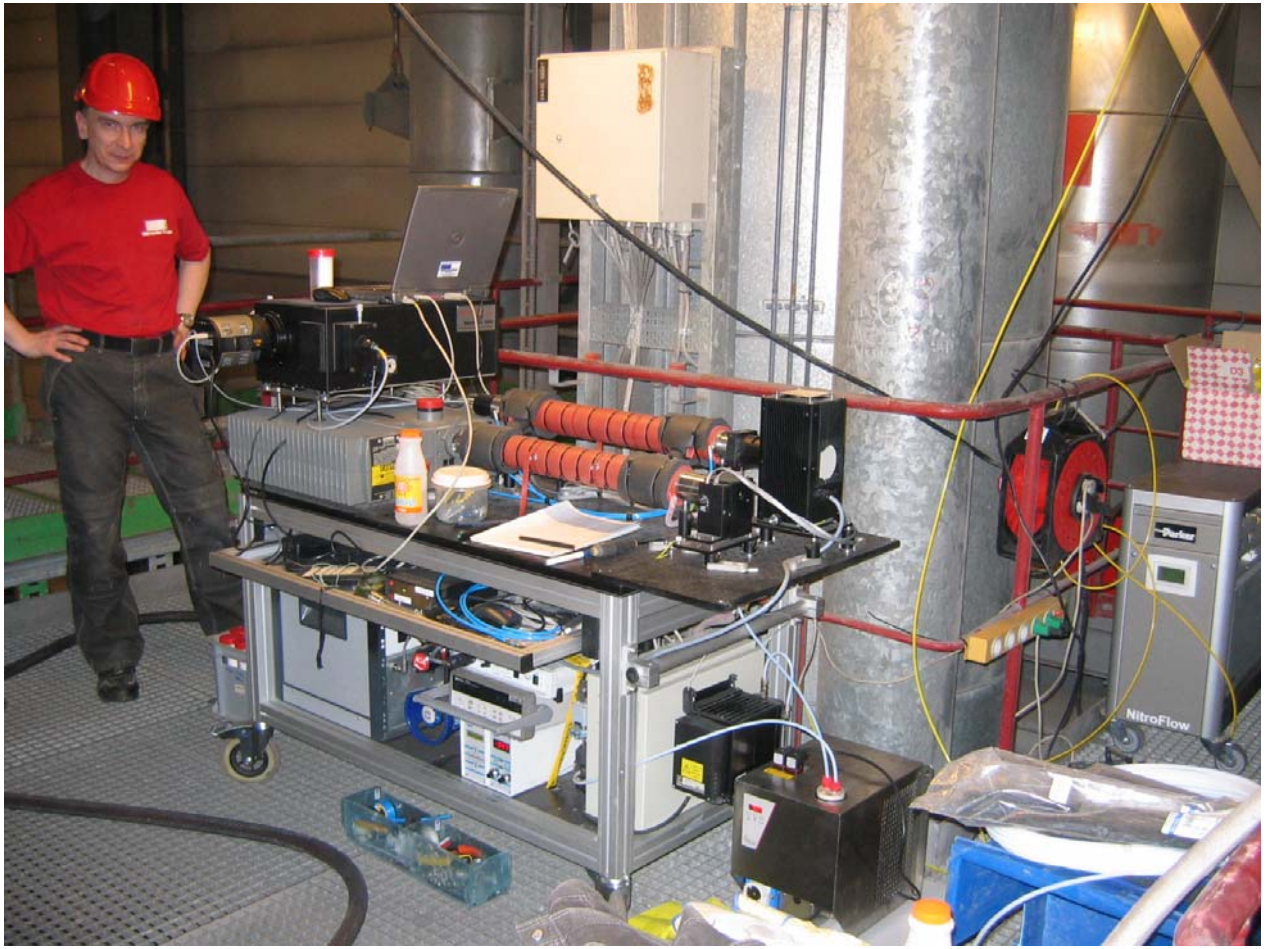


Modified ”Baxter” model

7 m probe Fynsværket

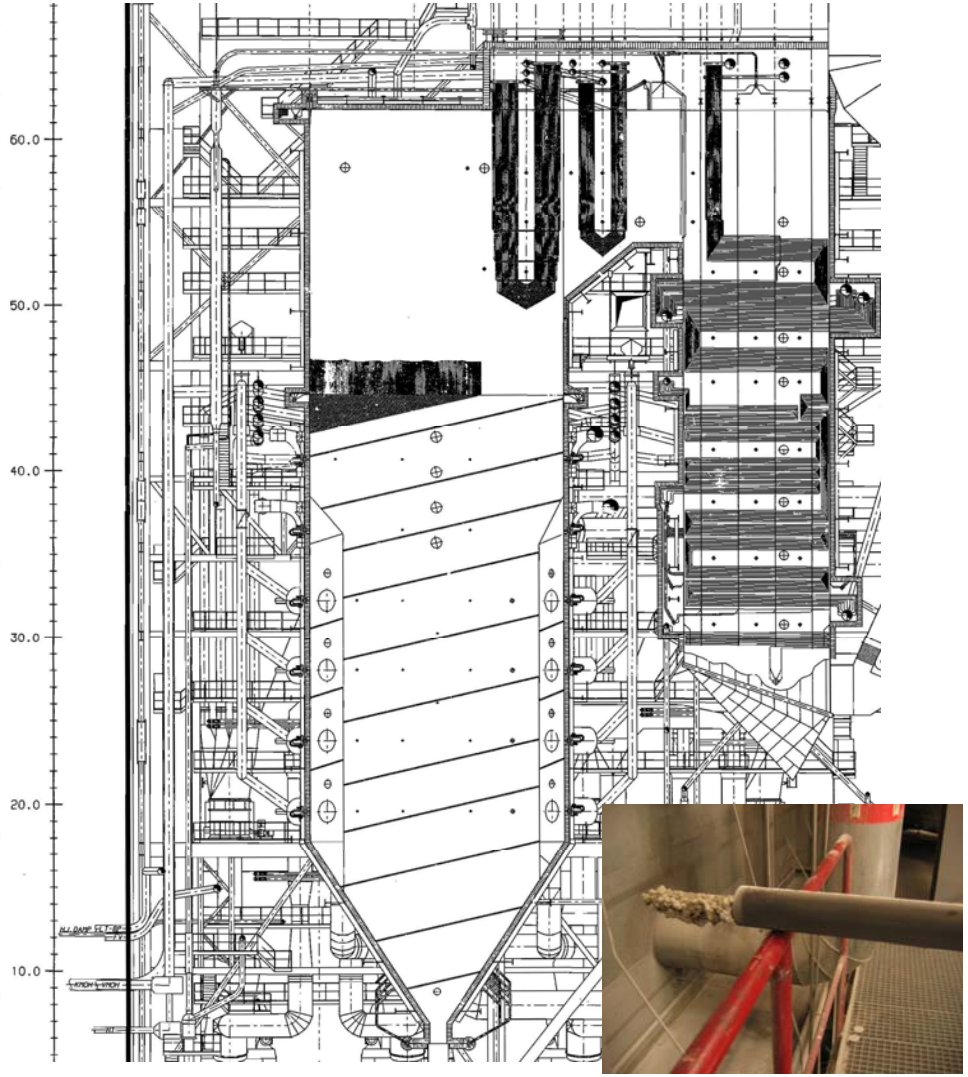


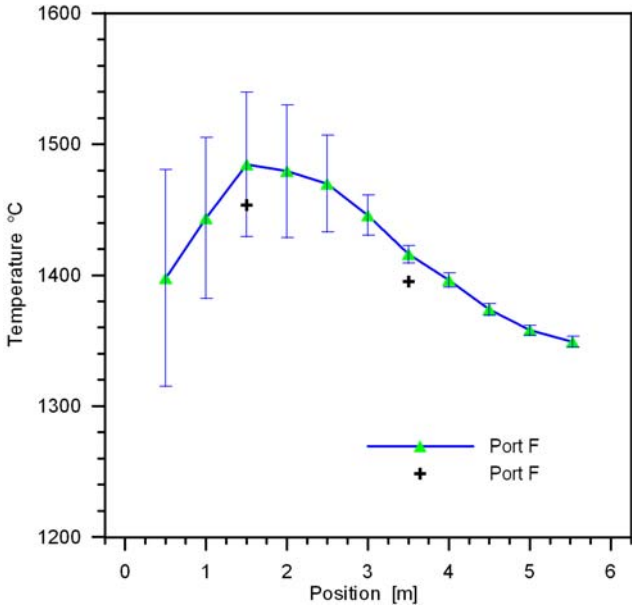
Extrative FTIR - UV

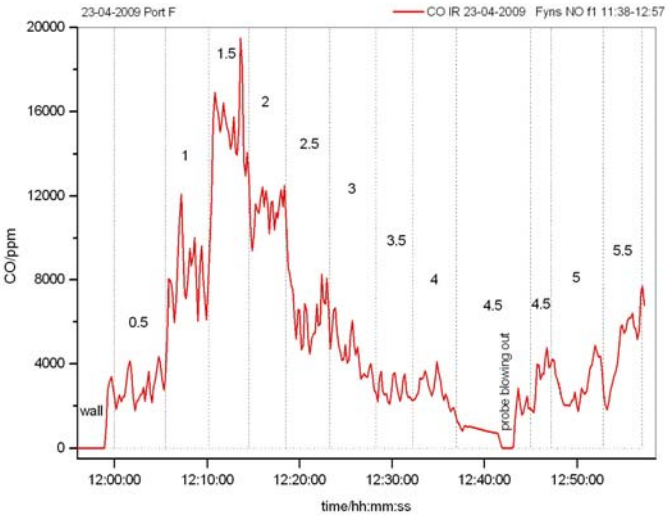


FYNSVÆRKET

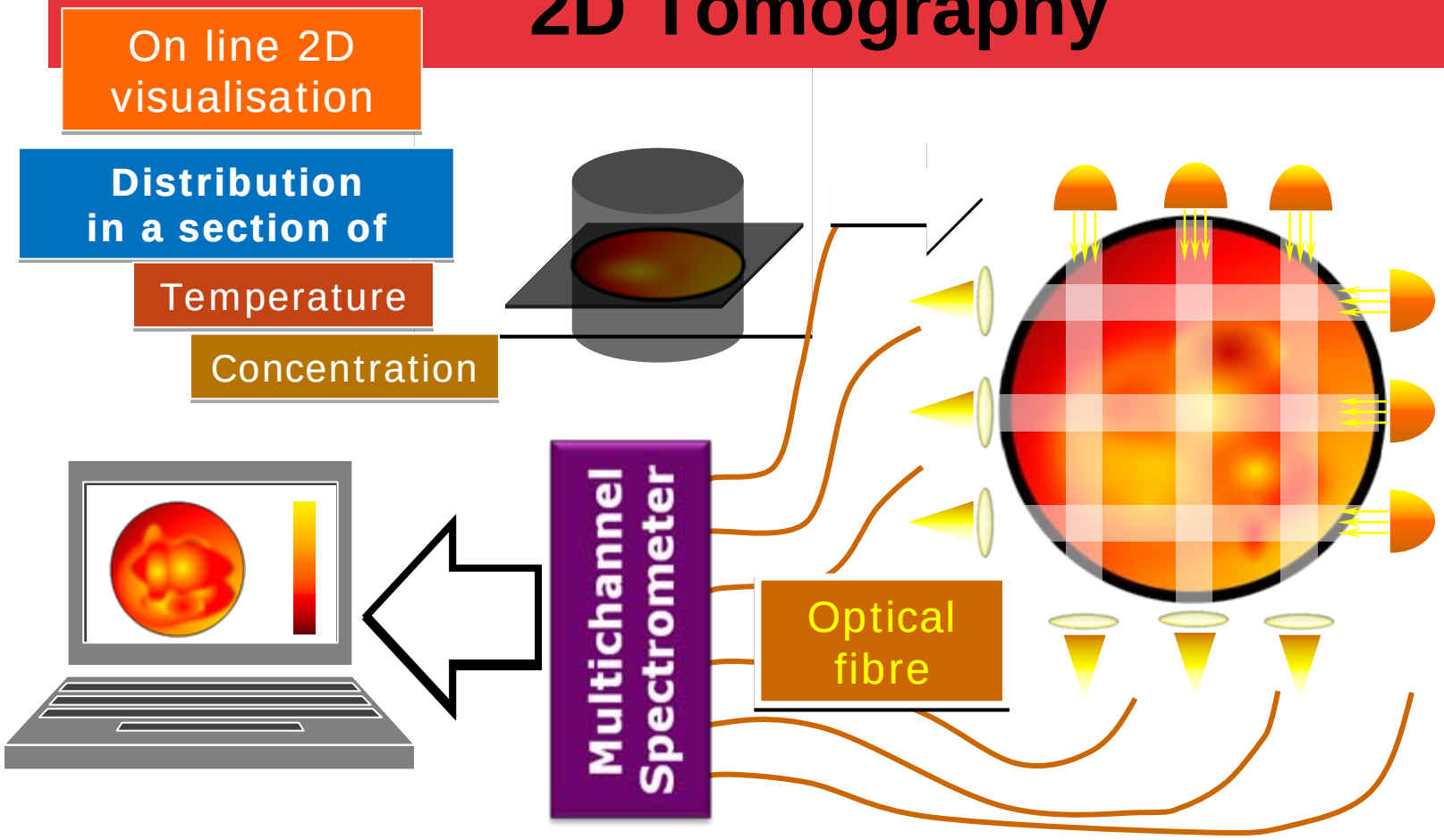
Apr. 2009







New diagnostic tools: **2D Tomography**



- 2D Tomography of e.g. hot gas inside of an exhaust pipe shows distribution of temperature or concentrations in a pipe section

CONCLUSION

- IR and UV fiber-optics powerfull tool
- Measurements in boilers and flames
- Mixing of flows
- Sensors

- New gas components?

sqcl@risoe.dtu.dk
+45 20814523